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## Are Acquired Dyslexias and Dysgraphias Language-specific or Universal?

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Key words: Acquired dyslexia and dysgraphia, cognitive neuropsychology, orthographic transparency, Turkish orthography, universal hypothesis.

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## Abstract

The aim of the current paper is to provide a review of the neuropsychology of acquired reading and writing impairments from an orthographic transparency perspective within the dual-route framework. Orthographic transparency refers to the ease with which one can directly predict phonology (sound) from orthography (print) in a given alphabetic writing system. Writing systems with highly predictable mappings between print and sound are said to be *transparent* (e.g. Turkish, Italian, Spanish) whilst unpredictable mappings between print and sound lead to *opaque* writing systems (e.g. English, French, Arabic). In addition, in some orthographies (such as Persian) transparent and opaque words coexist in print. The impact of orthographic transparency on normal (and impaired) language processing has led to the development of at least two opposing views, namely the orthographic depth hypothesis and the universal hypothesis. Ultimately the objective here is to demonstrate how neurological damage to the language area in the brain is linked to acquired dyslexia and dysgraphia *irrespective of orthographic transparency*. That is, neurological damage to the brain yields impairments that are *universal* in nature but perhaps manifested in a different way depending on the specific characteristics of the language. Evidence from atypically transparent Turkish orthography will be utilised to argue in favour of the universal hypothesis.

آیا نارساخوانی و نارسانویسی اکتسابی پدیده های خاص یک زبان است یا جهانی است؟

چکیده

هدف مقاله حاضر مروری بر نوروپسیکولوژی اختلالات اکتسابی خواندن و نوشتن از چشم انداز شفافیت خط در چارچوب انگاره دومسیری است.

منظور از شفافیت خط در یک نظام نوشتاری الفبایی میزان سهولت پیش بینی تلفظ از خط است. نظامهای نوشتاری که بازنمایی میان خط و تلفظ آنها بسیار قابل پیش بینی است شفاف محسوب می شوند (برای مثال، ترکی، ایتالیایی، اسپانیایی) درحالیکه بازنمایی غیرقابل پیش بینی میان خط و تلفظ منجر به نظامهای نوشتاری تیره می شود (برای مثال، انگلیسی، فرانسه، عربی). گذشته از این، در بعضی از خطها (مانند فارسی) واژه های شفاف و تیره در آن واحد در خط وجود دارند. تأثیر شفافیت خط بر پردازش زبانی طبیعی و مختل منجر به ایجاد حداقل دو دیدگاه متضاد شده است، یعنی، فرضیه عمق خط و فرضیه جهانی. نهایتاً هدف این مقاله این است که نشان دهد چگونه آسیب عصب شناختی به منطقه زبانی مغز - بدون توجه به شفافیت خط- با نارساخوانی و نارسانویسی اکتسابی در ارتباط است. یعنی، آسیب عصب شناختی به مغز منجر به اختلالاتی می شود که ماهیت جهانی دارند اما شاید بسته به ویژگیهای خاص هر زبان به شیوه ای متفاوت تظاهر پیدا می کند. شواهد برگرفته از خط شفاف ترکی برای استدلال در حمایت از فرضیه جهانی مورد استفاده قرار می گیرد.

## Introduction

The classification of alphabetic orthographies according to the directness with which they represent sound has been central in not only the development of models of normal reading and writing but also in the development of models of impaired reading and writing. Considerations in this respect focus on understanding the role of orthographic transparency on the underlying implications for cognitive processes in reading and writing. Historically, a leap in the domain of psycholinguistics is attributed to the proposal of the dual-route model (Coltheart, 1978) which was deep-rooted in the linguistic dichotomy of the English orthography, i.e. regularity between print and sound in English words (see Henderson 1982 for a comprehensive review). Regularity is of special interest here since it is very closely related to orthographic transparency. An English word is said to be regular if its pronunciation can be predicted correctly based on spelling-sound rules, e.g. MINT, and irregular when the application of these rules yields an incorrect pronunciation, e.g. PINT (see Venezky, 1970; Wijk, 1966, for spelling-sound rules in English). The basic tenet of the dual-route model (see Figure 1) is that there are at least two qualitatively distinct routes involved in converting print to sound. One is the lexical route (Route A) where previously stored information about words is assumed to be retrieved or addressed from the mental lexicon, i.e. the mental dictionary. The other is the nonlexical route (Route D) where phonology can be generated or assembled using print to sound translation rules. One major distinction between the two routes is that while the manner in which the mental lexicon is organised has implications on the operations of the lexical route, the nonlexical route is free of such influences.

Insert Figure 1 about here

One major controversy in this respect was whether the degree of lexical involvement is determined by orthographic transparency. According to the advocates of the orthographic depth hypothesis (e.g. Lukatela, Popadic, Ognjenovic, & Turvey, 1980), orthographic transparency *does* determine the degree of lexical involvement such that an effects for frequency should be minimal or completely absent for words in a truly transparent orthography. This is because all words in transparent orthographies can be read nonlexically (Route D). On the contrary, the proponents of the universal hypothesis (Baluch & Besner, 1991) argue that even in extremely transparent orthographies the lexical route is used by default in reading and that a reliable frequency effect is predicted for all languages *universally*. This is because irrespective of type of orthography, adult skilled readers primarily utilise the use of the lexical route during reading (Route A) as it is assumed to be more efficient and faster than the operations of the nonlexical route. Indeed, a reliable frequency effect from adult skilled readers in Turkish conclusively showed that even readers of completely transparent orthographies make primary use of the lexical route (Raman, Baluch & Sneddon, 1996). Therefore, the controversy between the two positions was resolved in favour of the universal hypothesis - at least where the transparent Turkish orthography was concerned.

It is important to note that acquired disorders refer to those as a result of neurological damage to the brain only. Insofar as acquired disorders such as dyslexia and dysgraphia are concerned, particularly in English, the diagnosis and classification is intertwined with the nature of representations (regularity) between phonology and orthography. Sound to print regularity has consequently been central in the development and implementation of models of spelling, such as the dual-route model of spelling (Ellis, 1984). The model, like to the dual-route model for reading,

comprises of two qualitatively distinct routes for deriving spelling: a nonlexical route for converting or assembling print from sound and a lexical route for retrieving or addressing the spelling of familiar words. Words (and nonwords) with regular sound to print mappings are assumed to be spelt using the nonlexical route whereas words with irregular mappings can be spelt using the lexical route, at least in English. The following is a brief description of three main types of dysgraphia, namely phonological, surface and deep dysgraphia.

Phonological dysgraphia is reported to correspond with an impaired ability to spell nonwords to dictation while familiar word spelling is fairly preserved (e.g. Bub & Ketes, 1982; Shallice, 1981). Within the dual-route model of spelling phonological dysgraphia has been interpreted to indicate impaired assembly of print from sound via the nonlexical route whilst the retrieval of previously learnt, familiar words via the lexical route is intact.

The most salient feature of surface dysgraphia is the better spelling of regular words than irregular words with a tendency to produce regularised versions of irregular spellings (e.g. Beauvois & Derouesne, 1981; Weekes, Davies, Parris, & Robinson, 2003). In surface dysgraphia intact nonword spelling is coincident with regularised spelling for irregular words. This is taken as evidence for an impaired lexical route whilst the operations of the nonlexical route are preserved.

Deep dysgraphia is characterized by a lexicality effect, i.e. the better spelling of words than nonwords, and an imageability effect, i.e. better spelling of high imageable words such as apple than low imageable words such as idea (e.g. Bub & Ketes, 1982; Hatfield, 1985). The main body of evidence supporting this classification emerged from orthographies with mixed (i.e. opaque and transparent) mappings between sound and print such as English and French (e.g. Beauvois &

Derouesne, 1979; Bub & Kertesz, 1982, and Marshall & Newcombe, 1973). The hallmark of deep dysgraphia is a lexicality effect, i.e. better spelling of words than nonwords, and an imageability effect, i.e. better spelling of high imageable words than low imageable words (Bub & Kertesz, 1982; Hatfield, 1985; Newcombe & Marshall, 1981). These impairments are taken as evidence for both an impaired nonlexical route and an impaired semantic system.

Despite this early body of evidence between dysgraphia and regularity, the influence of orthographic transparency on acquired dysgraphias in different languages has only recently come to attention. Extremely transparent languages are of particular interest since it was previously argued that neither dyslexia nor dysgraphia would exist in such orthographies (e.g. Ardila, 1991). This was because words (and nonwords) with such transparent mappings between print and sound could be read or written equally well by either the lexical or the nonlexical routes. Even if one of the routes was impaired, its functional role was assumed to be taken over by the other, intact route without any hindrance. Noteworthy is that this supposition conforms with the predictions of the orthographic depth hypothesis discussed previously for normal reading and spelling. Recent evidence, in particular from Italian and Spanish, however, suggest otherwise. Currently there are reports on developmental dysgraphia (Angelelli, Judica, Spinelli, Zoccolotti & Luzzatti, 2004) and acquired dysgraphia in Italian (e.g. Luzzi, Bartolini, Coccia, Provinciali, Piccirilli & Snowden, 2003; Miozzo & De-Bastiani, 2002) as well as reports of acquired dysgraphia in Spanish (e.g. Iribarren, Jarema & Lecours, 2001). In my view, these reports further substantiate the universality of language impairments irrespective of orthographic transparency as I will further discuss below.



Returning to reading impairments, phonological dyslexia is characterised by the poor reading of nonwords but spared ability to read real words. Within the dual-route framework, this is taken as evidence for the sole impairment of the rule-based nonlexical route which fails to generate phonology from orthography for nonwords (e.g. Funnell, 1983; Coltheart, Patterson & Marshall, 1980) whilst the lexical route is assumed to be intact and successful in retrieving phonological information for words.

In contrast, in surface dyslexia the readers' performance on nonword and regular word reading is laboured but good, whilst performance on irregular words is poor and typically accompanied by a high rate of regularisation errors. This is taken to suggest that there is a heavy reliance on the nonlexical route to read all words as the lexical route is selectively impaired (Shallice, Warrington & McCarthy, 1983). The discrepancy in performance on naming words and nonwords from phonological and surface dyslexias is often referred to as a *double dissociation* and taken to support the existence of two distinct routes for deriving phonology from print.

Evidence for the use of a third route (Route B-C), namely the orthographic-to-semantic route, was provided by deep dyslexia which is typically characterised by semantic errors in addition to the symptoms observed in phonological dyslexia. For example, when presented with the word TULIP deep dyslexics will often call out CROCUS (Coltheart, 1980; Saffran, Boggy, Schwartz and Marin, 1980). This has been taken to suggest that in deep dyslexia phonology is indirectly accessed via semantic representations with likely damage to both Route D (since nonword naming is also poor) and Route A.

Although both Italian and Spanish are repeatedly reported as examples of transparent writing systems in the literature, it is nevertheless important to note that predicting spelling from sound is hindered by irregularities, exceptions to the rule and

stress assignment (e.g. see Barry & Bastiani, 1997; Sebastián-Gallés, 1991; Cuetos, 1993 for details). Both orthographies have comparably more transparent mappings between print and sound than English and French, but neither print nor sound can be directly predicted from each other. In summary, spelling in Italian and Spanish is context dependent since some lexical knowledge is required to correctly spell to dictation at least some of the time.

Therefore it is of interest to examine writing impairments in languages in which orthography can be exclusively predicted from phonology. This is because such orthographies provide us with an ideal medium of investigation without the additional confounds of linguistic dichotomies such as regularity and stress assignment. An extreme example of a transparent writing system is Turkish orthography. Research directed at understanding the impact of direct mappings between orthography and phonology on cognitive processes in Turkish has only recently flourished (Raman, Baluch & Sneddon, 1996; Raman & Baluch, 2001; Raman, 2003; Raman, Baluch & Besner, 2004; Raman, 2006).

The modern Turkish orthography comprises of an adapted version of Latin with eight vowels and 21 consonants (see Table 1). The most salient aspect of Turkish orthography is the bi-directional transparency between orthography and phonology. That is, the pronunciation for words and nonwords in reading aloud as well as word and nonword spelling to dictation can be directly and correctly predicted (Raman, 2003). This is because each of the 29 letters in the orthography invariably corresponds to a single phoneme and vice versa.

Insert Table 1 about here

The important question that begs an answer here is the extent to which reading and writing disorders would be manifest in an orthography that is more transparent

than Italian and Spanish. Until most recently (Raman & Weekes, 2003; Raman & Weekes, 2005a; Raman & Weekes, 2005b), insofar as neuropsychology of reading and writing in Turkish are concerned, there had been no empirical reports in the literature. In a case study, Raman and Weekes (2005a) reported the first case of acquired dyslexia followed by a report of acquired dysgraphia (Raman & Weekes, 2005b) in a Turkish-English speaking patient, BRB. The following is a review and discussion of these findings in relation to orthographic transparency and universality of such disorders.

#### Case Report and Initial Assessment

A native speaker of Turkish from North Cyprus, BRB is a right-handed 67 year old man who suffered a cerebrovascular accident (CVA) in November 1999. BRB suffered from severe loss of speech after the stroke and a CT scan revealed a medium sized left temporal parietal-occipital lobe infarction (see Fig 2). BRB was also educated in English between the ages of 11 and 21. He is a retired senior civil servant from North Cyprus where Turkish is the official language.

Insert Figure 2 about here

Initial assessment showed that BRB's short term auditory-verbal memory problems were profound, e.g., he displayed very poor performance on the Digit Span test in Turkish = 1 forwards and 1 backwards and English = 1 forwards and 1 backwards. Moreover, BRB showed symptoms of deep dysphasia i.e., word and nonword repetition was poor in both languages demonstrating impairment to phonological representations for words in English and Turkish (Raman & Weekes, 2003). In contrast to the dysphasia, i.e., repetition problems observed with nonwords, BRB did well in naming them (Raman & Weekes, 2005a). However, he was reported

to be surface dyslexic in English with a lexical deficit in Turkish (Raman & Weekes, 2005a). BRB also performed well on PALPA (Kay, Lesser & Coltheart, 1992) Test No. 48, written word-picture matching task, scoring 38/40. This indicates that mappings between orthography and semantics are rather intact.

#### Outcome of Tests of Reading

Although BRB's ability to name nonwords was equally preserved in English and Turkish, he nevertheless demonstrated script specific impairments when reading words. BRB showed typical symptoms of surface dyslexia in English with regularising irregular words; whilst in Turkish he showed an imageability effect in naming words. In conclusion, Raman and Weekes (2005a) confirmed that a) acquired dyslexia exists in the totally transparent Turkish orthography; b) the dissociation between lexical and nonlexical processing is evident in preserved nonword reading via the nonlexical route whereas word reading via the lexical route is impaired; c) lexical reading problems in Turkish correlate with phonological impairments.

#### Outcome of Tests of Spelling

BRB made semantic errors in spelling English and Turkish words as well as an effect of grammatical class. In spelling to dictation he made semantic errors to homophones (i.e. words that sound the same e.g. GREAT/GRATE) in English, e.g. PAIN was written as WOUND; and in Turkish he made semantic errors such as writing AĞAÇ *tree* as BAHÇE *garden*; AYAKKABI *shoe* as KUNDURA *local flat shoe* and GÜNEŞ *sun* as GÜNDÜZ *day*. Collectively the pattern of results indicates that BRB acquired deep dysgraphia in Turkish and English. Furthermore, comparable impairments in Turkish and English are perhaps indicative to a *common locus* of manifestation in the biscriptal reader. Within the cognitive neuropsychological framework of dysgraphia, BRB's pattern of spelling errors appear to be in line with

features of deep dysgraphia in relatively opaque languages, suggesting that a lexical semantic spelling process is available for spelling in Turkish. Moreover, the existence of acquired dysgraphia was confirmed in a totally transparent orthography.

## Discussion and Conclusion

Evidently, the data from BRB make a contribution to understanding writing and reading in Turkish and more broadly to our understanding of acquired dysgraphia and dyslexia in extremely transparent writing systems. It is also very clear that damage to the normal reading and writing system as a result of neurological damage has clear links with acquired reading and writing problems in Turkish. Damage to phonological representations for Turkish words (poor spoken and written picture naming and repetition) subsequently lead to difficulties in reading and writing in a previously highly literate individual. Although BRB's reading of Turkish words including picture names was remarkably well preserved, his ability to read aloud low imageability words was impaired. This impairment was coincident with surface dyslexia for English words whereby irregularly spelt and inconsistent words were read poorly.

The pattern of data overall shows that damage to the mappings between phonology, orthography *and* semantics will have a consequence for both languages, i.e. universal presentation, of a biscriptal reader although these manifest themselves differentially according to the finer properties of the script and the type of task. Because English has a number of inconsistent mappings between orthography and phonology, the loss of semantic support will result in a pattern of errors consistent with deep dysgraphia. By contrast, a loss of semantic support has less consequence for Turkish spelling because there are no unpredictable mappings between

orthography and phonology in the first place. However, this does not mean that normal writing (and reading) of Turkish words does not also call for semantic support. Spelling performance is likely to be compromised by phonological impairments whereas reading is well preserved. My view is that normal reading and spelling in Turkish requires the operation of a lexical and nonlexical route; in addition, the lexical route provides semantic support when reading low imageability words. The imageability effect reported for BRB is due to greater reliance on semantic support for low imageability items. Thus one can reason that just as in less transparent orthographies, semantics must be automatically activated in reading Turkish also. Low imageability words are more error prone as they take longer than high imageability words to activate phonology because of sparse representations. Collectively, there is evidence to suggest that BRB's impairments have a common locus. Specifically, loss of semantic support affects the reading of low imageability words and irregular words in any script. BRB's spelling to dictation was more severely compromised than reading in both Turkish and English. This further suggests that even relatively proficient Turkish readers may struggle with the task of spelling to dictation particularly if the words to be spelled are low in imageability or phonologically complex.

Finally, what are the implications of the findings from acquired language disorders in Turkish and other highly transparent writing systems on developmental dyslexia and dysgraphia in Turkish? One firm conjecture is that developmental reading and writing disorders *ought* to exist in Turkish. A noticeable absence of reports on the topic should not be taken to indicate that such difficulties do not occur. The simple and direct mappings between orthography and phonology is likely to *disguise* difficulties due to phonological deficits associated with developmental

dyslexia in less transparent or opaque writing systems (see Zeigler & Goswami, 2005 for a recent review). I speculate that for the accurate diagnosis and classification of developmental dyslexias and dysgraphias in Turkish, one ought to advance beyond the mappings between phonology and orthography. This is because the simple and consistent rules in converting print to sound may act as a smoke-screen concealing impaired processing in Turkish and indeed in other extremely transparent orthographies. The agglutinative property of the Turkish language could well provide a much enhanced medium for investigation by exploring the underlying mechanisms of its complex morphological structures. Research into the impact of morphology on reading and writing is currently a generally understudied area in both intact and impaired language processing. Understanding whether morphological properties of a given language influences processes such as reading and spelling will shed light on theory and assessment of developmental and acquired disorders.

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Figure 1: Dual-route model of naming, adapted from Besner (1999)

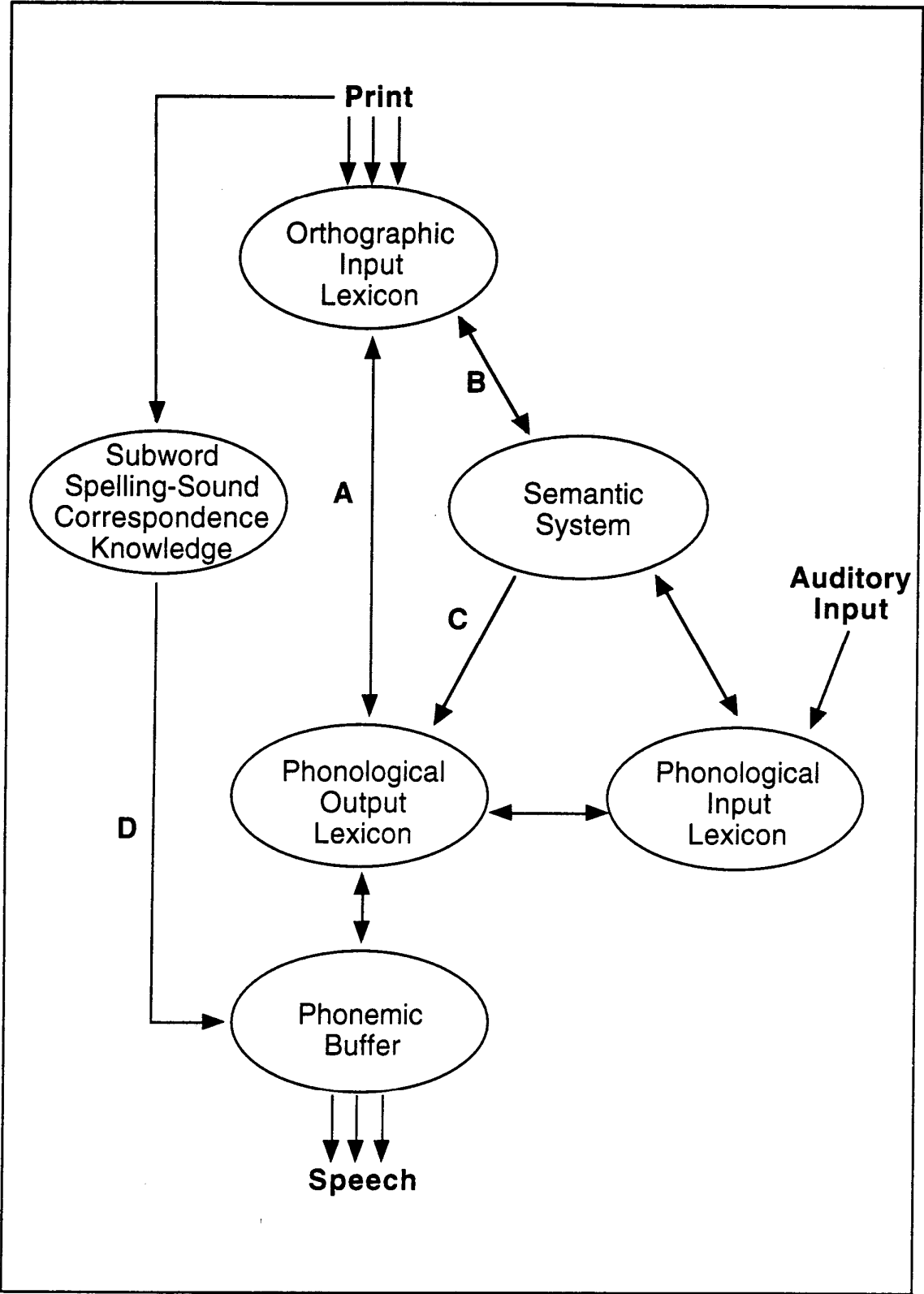


Figure 2: CT scan showing BRB's left temporal lesion after CVA (from Raman & Weekes, 2005b)

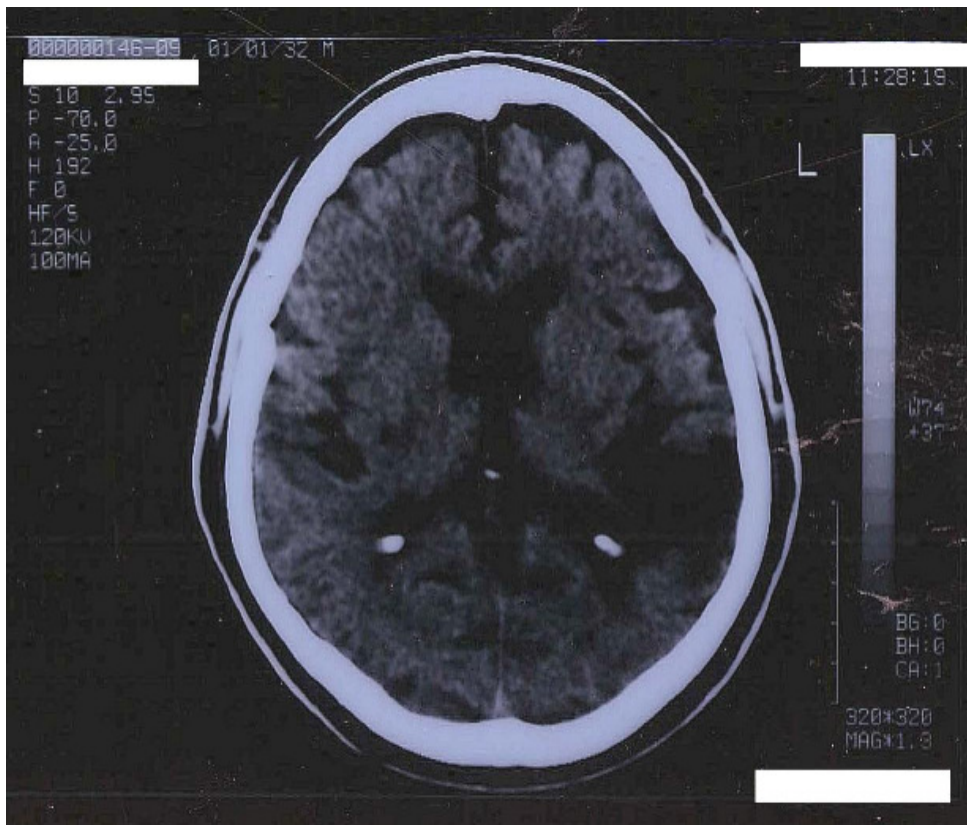


Table 1: Shared and distinct letters in Turkish and English alphabets (Letters unique to each alphabet are in bold)

Turkish alphabet	a b c <b>ç</b> d e f g <b>ğ</b> h <b>ı</b> i j k l m n o <b>ö</b> p r s <b>ş</b> t u <b>ü</b> v y z
English alphabet	a b c d e f g h i j k l m n o p <b>q</b> r s t u v <b>w</b> <b>x</b> y z